

# Image Enhancement Using Histogram Equalization and Histogram Specification on Different Color Spaces

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*A thesis submitted in partial fulfillment for the degree of*  
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*under the guidance of*  
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## Certificate

This is to certify that the work in the project entitled Image Enhancement Using Histogram Equalization and Histogram Specification on Different Color Spaces by Pankaj Kumar is a record of their work carried out under my supervision and guidance in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Computer Science and Engineering.

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# **Abstract**

Image Enhancement is one of the important requirements in Digital Image Processing which is important in making an image useful for various applications which can be seen in the areas of Digital photography, Medicine, Geographic Information System, Industrial Inspection , Law Enforcement and many more Digital Image Applications. Image Enhancement is used to improve the quality of poor images. The focus of this paper is an attempt to improve the quality of digital images using Histogram Equalization and Histogram Specification. In this paper we are applying Histogram Equalization on color images with Different Color Space like RGB ,HSV ,YIQ and Histogram Specification on gray Scale images and color images.

# Contents

<b>Certificate</b>	<b>i</b>
<b>Acknowledgement</b>	<b>ii</b>
<b>Abstract</b>	<b>iii</b>
<b>List of Figures</b>	<b>vi</b>
<b>1 Introduction</b>	<b>1</b>
1.1 Image . . . . .	1
1.2 Types of Images . . . . .	2
1.3 Image Processing . . . . .	2
1.4 Image Enhancement . . . . .	3
1.5 Existing Techniques For Image Enhancement . . . . .	3
<b>2 Histogram Equalization</b>	<b>6</b>
2.1 Histogram Equalization . . . . .	6
2.2 Histogram Equalization on Color Image . . . . .	8
2.2.1 Equalize R, G, B components independently (method 1) . . .	8
2.2.2 Equalize the V Component from HSV Color Space (method 2)	9
2.2.3 Equalize the Y Component from YIQ Color Space (method 3)	9
2.3 Results: . . . . .	10
2.3.1 Gray Scale Image: . . . . .	10
2.3.2 Color Image . . . . .	12
<b>3 Histogram Specification</b>	<b>16</b>
3.1 Histogram Specification . . . . .	16

3.2	Results: . . . . .	17
3.2.1	Gray Scale Image: . . . . .	17
3.2.2	Color Image . . . . .	19
<b>4</b>	<b>Conclusion</b>	<b>21</b>
	<b>Bibliography</b>	<b>22</b>

# List of Figures

1.1	An image: an array or matrix of pixels arranged in columns and rows	1
2.1	Seed Image and its histogram[1] . . . . .	7
2.2	Block diagram showing the implementation of Method 1 . . . . .	8
2.3	Image of family, its Histogram, Equalized family Image and Histogram	10
2.4	forest image with whiteness, Equalized Image and its histogram . . .	11
2.5	Image of seeds, Equalized Image and its histogram . . . . .	11
2.6	Image of forest, Equalized Image and its histogram . . . . .	12
2.7	Image of flower, Equalized Image and its histogram . . . . .	12
2.8	Image of tower, Equalized Image and its histogram . . . . .	13
2.9	Image of Building, Equalized Image with YIQ and its Histogram . . .	14
2.10	Image of Flower, Equalized Image with YIQ and its Histogram . . . .	14
2.11	Image of Tower, Equalized Image with YIQ and its Histogram . . . .	15
3.1	Image of moon and Histogram Specified Image . . . . .	17
3.2	Image of Tire and Histogram Specified Image . . . . .	18
3.3	Image of Space and Histogram Specified Image . . . . .	18
3.4	Image of Retinal, reference image and Output Image . . . . .	19
3.5	Input image, reference image and output image . . . . .	20

# Chapter 1

## Introduction

### 1.1 Image

An image is an array, or a matrix, of square pixels (picture elements) arranged in columns and rows .An Image is a 2D function  $f(x,y)$ , where  $x$  and  $y$  are spatial coordinates and amplitude of  $f$  at any pair of coordinates  $(x,y)$  is called the intensity or gray level of the image.



Figure 1.1: An image: an array or matrix of pixels arranged in columns and rows



## 1.2 Types of Images

**Binary Image** Are the simplest types of images and they take discrete values either 0 or 1 hence called binary images. Black is denoted by 1 and white by 0. These images have application in computer vision and used when only outline of the image required.

**Gray scale images** They are also known as monochrome images as they do not represent any color only the level of brightness for one color. This type of image consists of only 8 bytes that is 256(0 – 255) levels of brightness 0 is for black and 255 is white in between are various levels of brightness.

**Colored images** Usually consist of 3 bands red green and blue each having 8 bytes of intensity. The various intensity levels in each band is able to convey the entire colored image it is a 24 bit colored image.

## 1.3 Image Processing

Image processing includes methods to convert a real time object/ image into digital image form and perform some operations on it, in order to get an enhanced image or to extract some useful information from it[1].

### Image Processing Techniques

- Image representation
- Image preprocessing
- Image enhancement
- Image restoration
- Image analysis

- Image segmentation
- Image data compression

## 1.4 Image Enhancement

The main objective of image enhancement is to process the image so that the output image will be better compared to input image. So this technique enhances and improves the quality of the image.

- Highlighting interesting details in images.
- Making images more visually appealing

## 1.5 Existing Techniques For Image Enhancement

- Image Negative
- Log Transformation
- Grey Level Slicing
- Contrast Stretching
- Bit Plane Slicing
- Power Law Transformation

**Image Negative** The negative of image with gray levels in the range  $[0, L-1]$  is obtained by negative transformation.

$$s = L - 1 - r \quad (1.1)$$

Here

$r$  is input gray level

$s$  is output gray level

This type of processing is suited for enhancing white or gray detail embedded in dark levels of an image, when the black areas are more in size.

**Log Transformation** The log transformation of image with gray levels in the range  $[0, L - 1]$  is obtained by log transformation.

$$s = c \log(1 + r) \quad (1.2)$$

where  $c$  is constant.

This transformation maps a limited range of low gray level values in the input image into a wider range of output levels. This transformation used for expand the values of dark pixels in an image while compressing the higher level values.

**Power Law Transformation** The power law transformation of image with gray levels in the range  $[0, L - 1]$  is obtained by power law transformation.

$$s = cr^\gamma \quad (1.3)$$

where  $c$  &  $\gamma$  are constants.

Power law curves with fractional values of maps a narrow range of dark input values into a wider range of output values. Devices used for image capture , printing and display respond according to a power law.

**Contrast Stretching** This method is used for increasing the dynamic range of gray levels in the image. Low contrast images can result from poor illumination , lack of dynamic range in the image sensor , wrong setting of lens aperture during image acquisition.

**Gray Level Slicing** Main objective is show a specific range of gray levels Show a high value for all gray levels in the range of interest and a low value for all other gray levels : produce a binary image Brighten the desired range of gray levels, but maintain the background and gray level tonalities

**Bit Plane Slicing** Each pixel is represents by 8 bits.so image is comprised of eight 1-bit planes. Separating a digital image into its bit planes is useful for analyzing the relative importance played by each bit of the image, a process that aids in determining the adequacy of the number of bits used to quantize each pixel. This type of decomposition is useful for image compression .

# Chapter 2

## Histogram Equalization

An image histogram is a type of histogram that acts as a graphical representation of the tonal distribution in a digital image. It plots the number of pixels for each tonal value. A histogram is a representation of a frequency distribution. The histogram of a digital image with  $G$  total possible intensity levels in the  $[0, G - 1]$  is defined as the discrete function:

$$p(r_k) = \frac{n_k}{n} \quad (2.1)$$

Where  $r_k$  is the intensity level in the original raw image  $n_k$  is the number of pixels in the image whose intensity level is  $n$  is the total no of pixels.

### 2.1 Histogram Equalization

Histogram equalization is used to enhance the contrast of the image, it spreads the intensity values over full range. Histogram equalization technique can't be used for images suffering from non-uniform illumination in their backgrounds as this process only adds extra pixels to the light regions of the image and removes extra pixels from dark regions of the image resulting in a high dynamic range in the output image. The goal of histogram equalization is to spread out the contrast of a given image evenly throughout the entire available dynamic range.

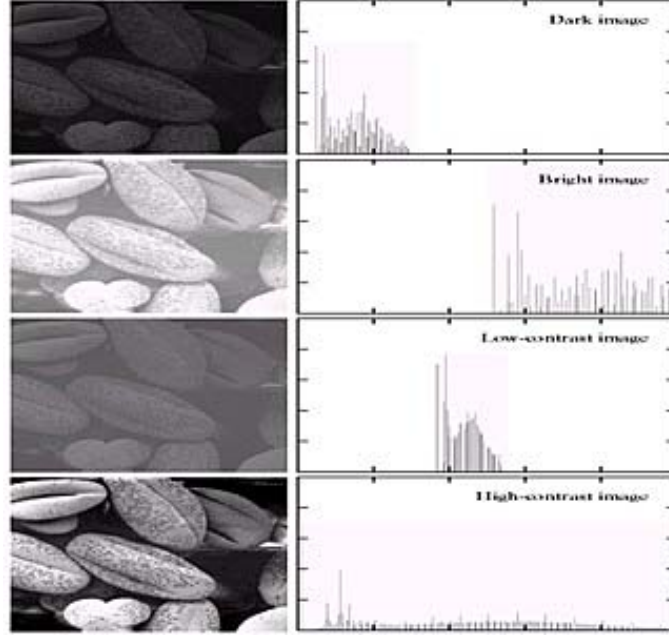


Figure 2.1: Seed Image and its histogram[1]

In histogram equalization technique, it is the probability density function (pdf) that is being manipulated. To make it simple, what histogram equalization technique does is that, it changes the pdf of a given image into that of a uniform probability density function that spreads out from the lowest pixel value (0 in this case) to the highest pixel value ( $L - 1$ ). This can be achieved quite easily if the pdf is a continuous function. However, since we are dealing with a digital image, the pdf will be a discrete function. Lets suppose we have an image  $x$ , and let the dynamic range for the intensity  $r_k$  varies from 0 (black) to  $L-1$  (white). This pdf can be approximated using the probability based on the histogram  $p(r_k)$  as follow:

$$pdf(x) = p(r_k) = \frac{\text{total pixels with intensity } r_k}{\text{total pixels I image } x} \quad (2.2)$$

From this pdf, we can then obtain the cumulative density function (cdf) as follows:

$$cdf(x) = \sum_{k=0}^{L-1} p(r_k) \quad (2.3)$$

Where  $p(r_k)$  is the probability for pixel of intensity. The output of a pixel from the histogram equalization operation is then equal to the cdf of the image or

mathematically :

$$p(s_k) = \sum_{k=0}^{L-1} p(r_k) \quad (2.4)$$

To get the value of the pixel,  $p(s_k)$  needs to be multiplied by  $L1$  and then round it to the nearest integer.

## 2.2 Histogram Equalization on Color Image

### 2.2.1 Equalize R, G, B components independently (method 1)

This scheme is one of the mostly used methods for color image processing. Each channels of RGB space are processed using Histogram Equalization independently[2]. After the Equalize the R,G,B components we concatenate all the three components and get the better image compare to input image .

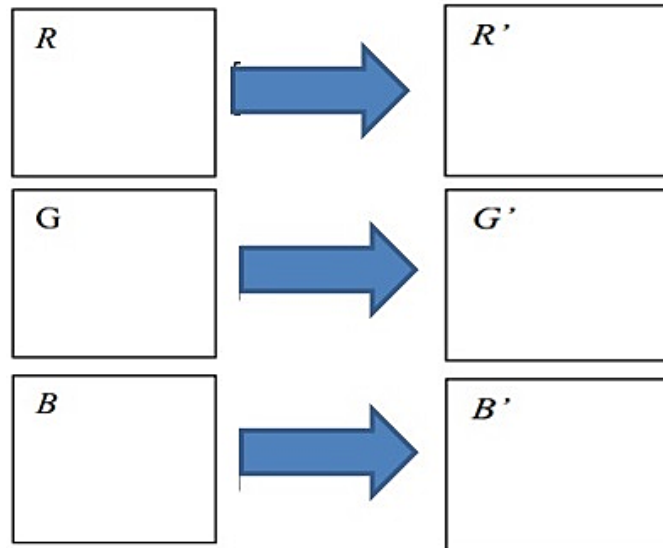


Figure 2.2: Block diagram showing the implementation of Method 1

### 2.2.2 Equalize the V Component from HSV Color Space (method 2)

In order to process color image in RGB color space using this scheme, image first must be transformed to hue, saturation and luminance (HSV) color space. Here Brightness is a synonym of intensity. Hue represents the impression related to the dominant wavelength of the color stimulus. Saturation shows the relative color purity (amount of white light in the color).

Hue and Saturation taken together are called the chromaticity coordinates (polar system).

In this method we apply the Histogram Equalization on V component on HSV color space. After the Equalize the V we combine the V with H and S. Then we get the better image compare to input image.

$$\text{HSV} \rightarrow \text{H}, \text{S}, \text{V}$$

$$\text{V} \rightarrow \text{V}(\text{equalize})$$

$$\text{HSV}(\text{equalize}) \rightarrow \text{H}, \text{S}, \text{V}(\text{equalize})$$

### 2.2.3 Equalize the Y Component from YIQ Color Space (method 3)

In order to process color image in RGB color space using this scheme, the image first must be transformed to YIQ color space[4][5].

Here

The Y component represents the luma information, and is the only component used by black-and-white television receivers.

I stands for in-phase

Q stands for quadrature

I and Q represent the chrominance information.

In this method we apply the Histogram Equalization on Y component on YIQ color space. After the Equalize the Y we combine the Y with I and Q. Then we get



the better image compare to input image .

$YIQ \rightarrow YIQ$

$Y \rightarrow Y(\text{equalize})$

$YIQ(\text{equalize}) \rightarrow Y, I, Q(\text{equalize})$

## 2.3 Results:

### 2.3.1 Gray Scale Image:

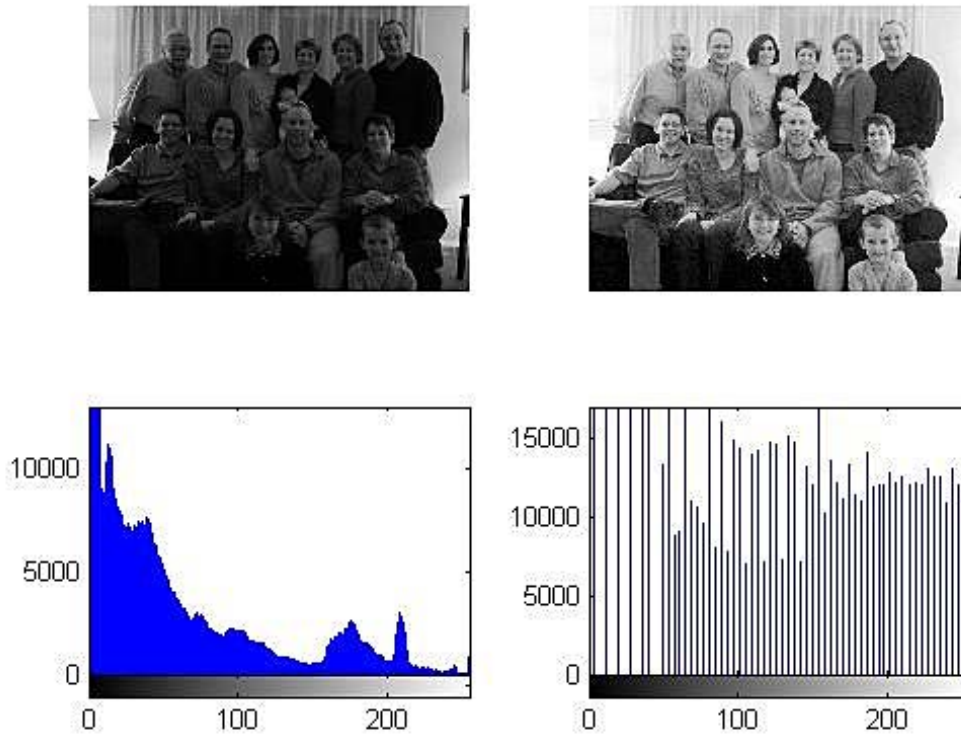


Figure 2.3: Image of family, its Histogram, Equalized family Image and Histogram

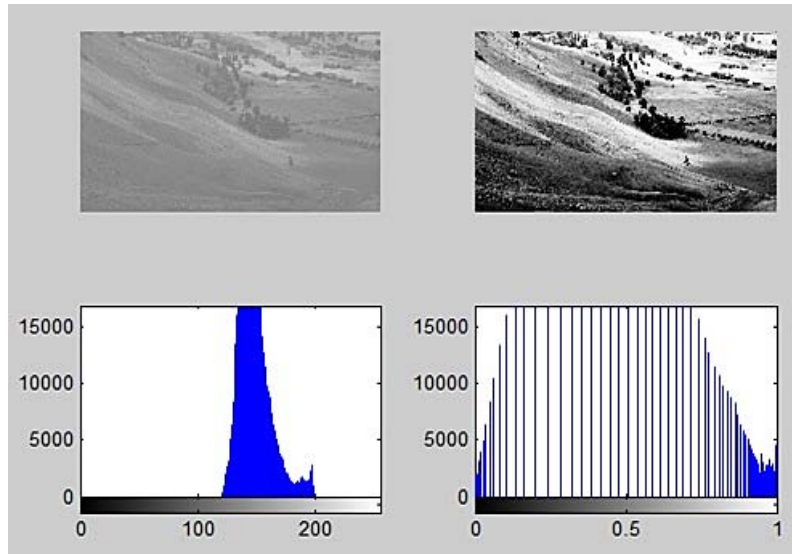


Figure 2.4: forest image with whiteness, Equalized Image and its histogram

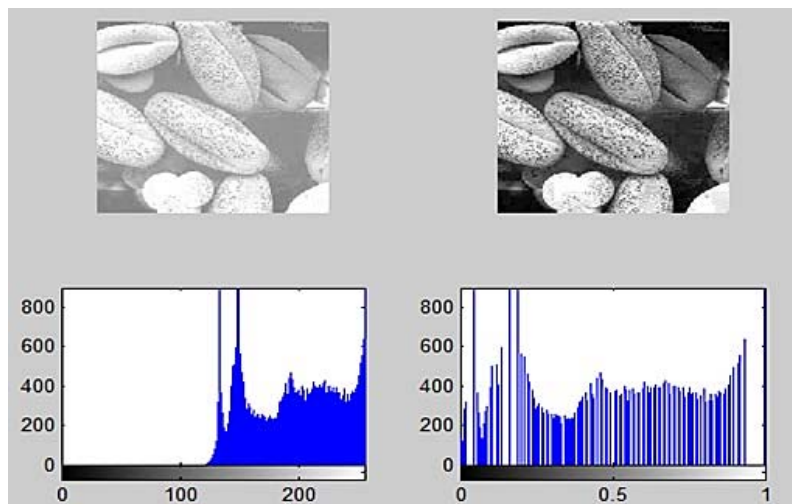


Figure 2.5: Image of seeds, Equalized Image and its histogram

### 2.3.2 Color Image

Using RGB Color Space :

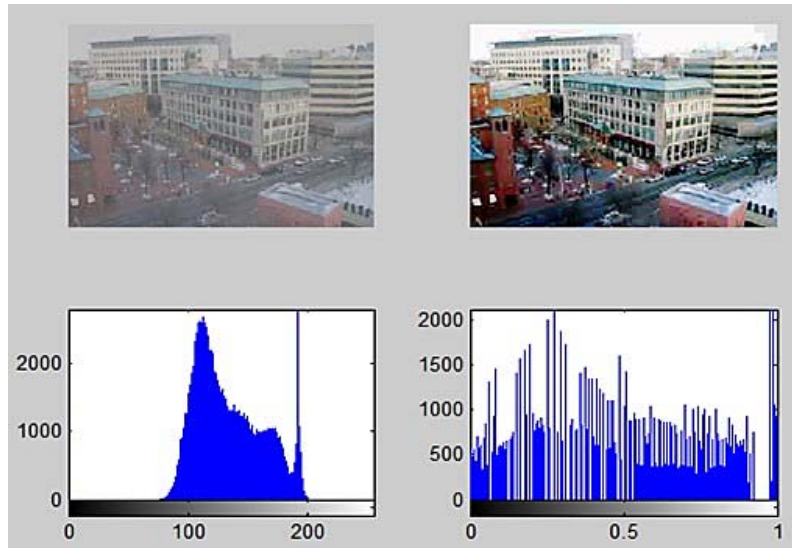


Figure 2.6: Image of forest, Equalized Image and its histogram

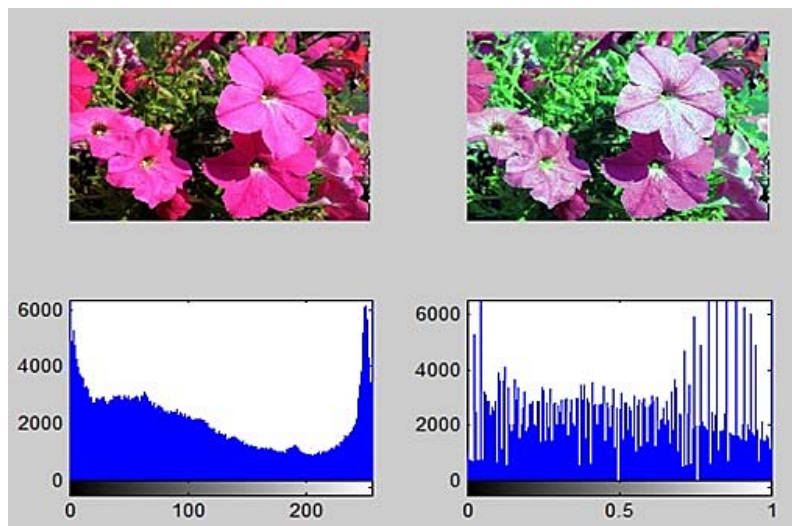


Figure 2.7: Image of flower, Equalized Image and its histogram

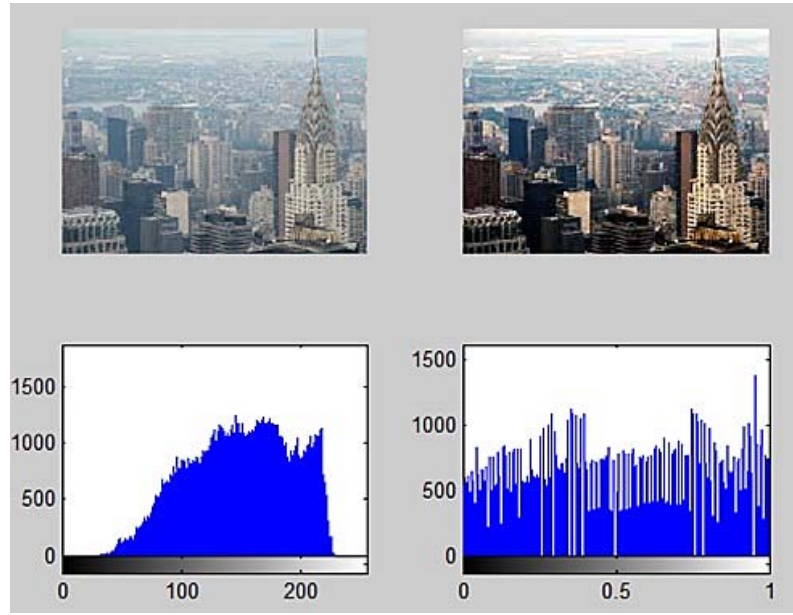


Figure 2.8: Image of tower, Equalized Image and its histogram

Using YIQ Color Space :

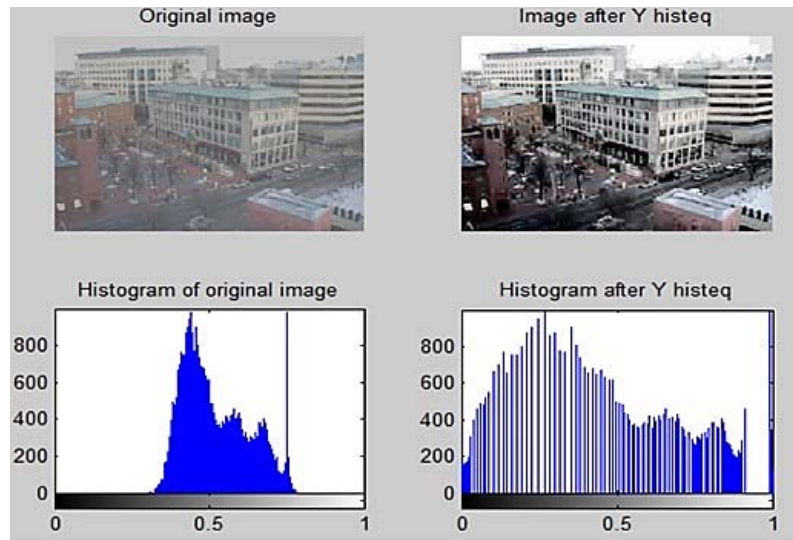


Figure 2.9: Image of Building, Equalized Image with YIQ and its Histogram

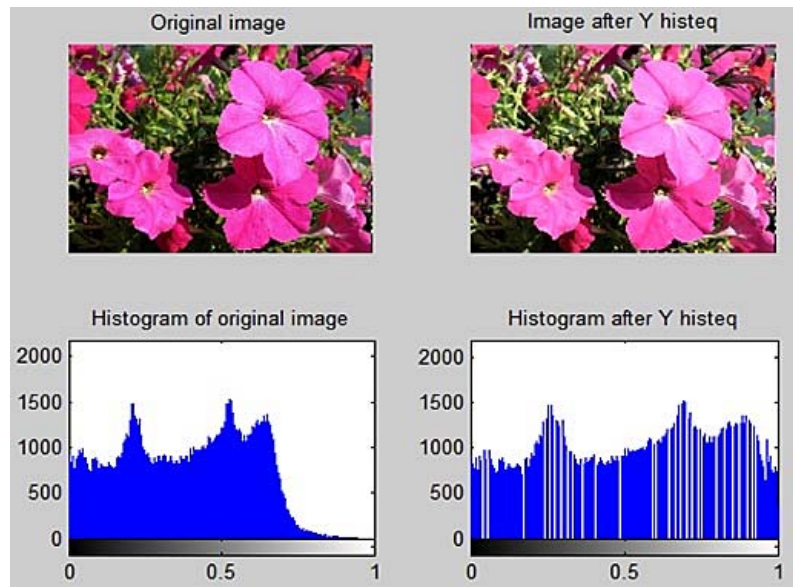


Figure 2.10: Image of Flower, Equalized Image with YIQ and its Histogram

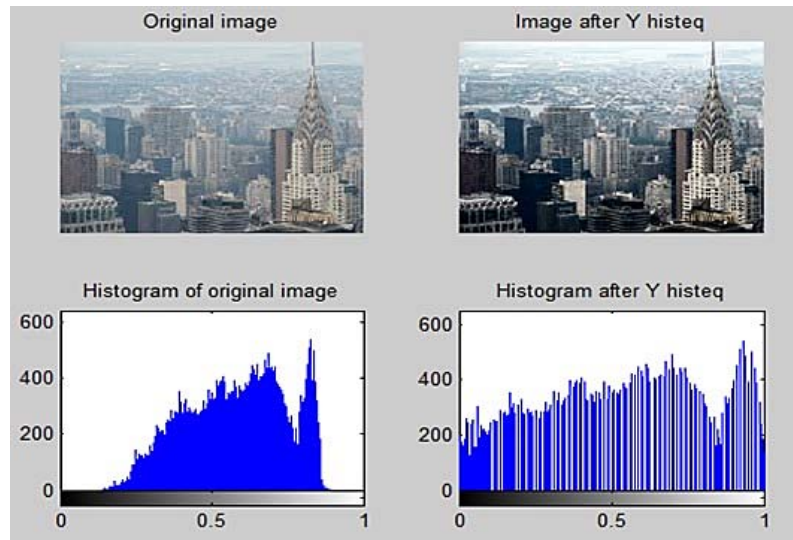


Figure 2.11: Image of Tower, Equalized Image with YIQ and its Histogram

# Chapter 3

## Histogram Specification

### 3.1 Histogram Specification

Histogram Specification is an extension to the histogram equalization technique. In histogram equalization technique, what we are trying to achieve is that the output histogram should follow the uniform pdf. But, for histogram specification, we want the output histogram to follow according to the histogram we specify. To achieve this, we first histogram equalize the input image, then the pdf of this resulting equalized image will be matched to the pdf of the desired histogram[3].

Let  $r$  and  $s$  be the pixel values for the input and equalized image respectively, and let  $z$  be the pixel value for the desired histogram. However, at this juncture the computation is only up to finding  $p(s(k))$  only i.e. the actual pixel value will be done at the end of the process. Then the cdf of the desired histogram i.e.  $p(z(k))$  is computed. Finally, for every  $p(s(k))$ , the nearest  $p(z(k))$  is sought. The corresponding  $s(k)$  then is multiplied by  $L+1$  to get the actual output value.

For Discrete levels we have :

$$r_k = T(r_k) = \sum_{j=0}^k \frac{n_j}{n}, \quad for\ 0 \leq k \leq L-1 \quad (3.1)$$

$$v_k = G(z_k) = \sum_{j=0}^k p_{out}(z_j), \quad for\ 0 \leq k \leq L-1 \quad (3.2)$$

It then follows from these two equations that  $G(z) = T(r)$  and, therefore, that  $z$  must satisfy the condition:

$$z_k = G^{-1}(T(r_k)) \quad (3.3)$$

## 3.2 Results:

### 3.2.1 Gray Scale Image:

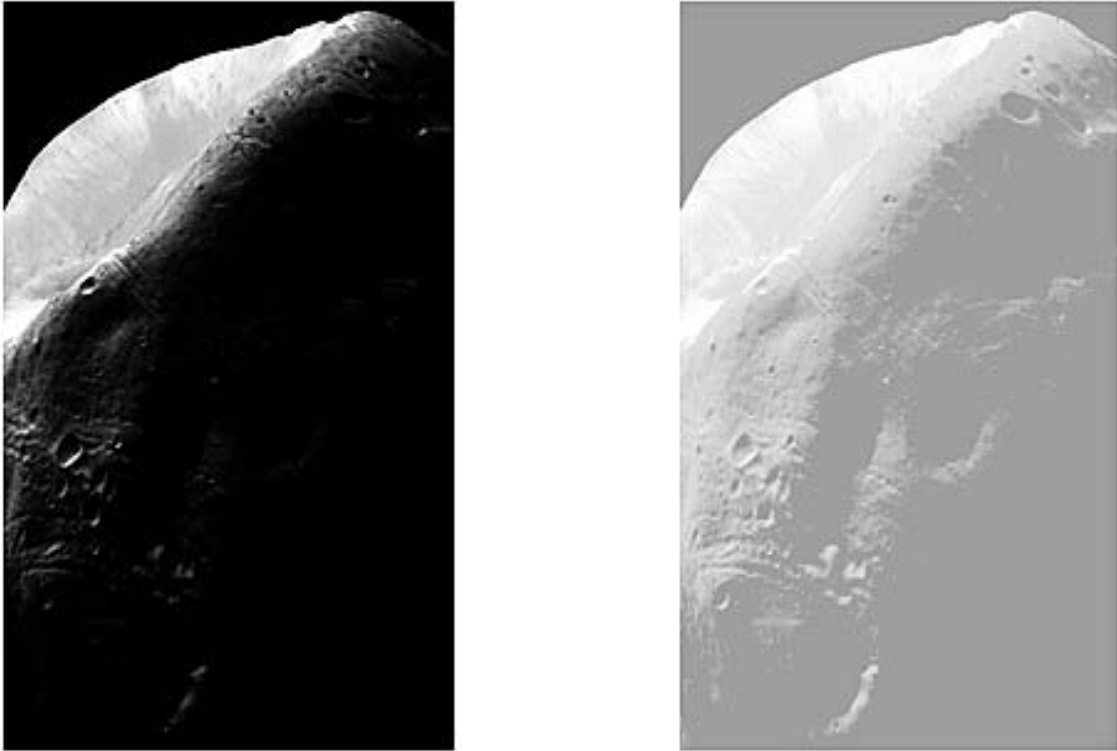


Figure 3.1: Image of moon and Histogram Specified Image





Figure 3.2: Image of Tire and Histogram Specified Image



Figure 3.3: Image of Space and Histogram Specified Image

### 3.2.2 Color Image

Using RGB Color Space :

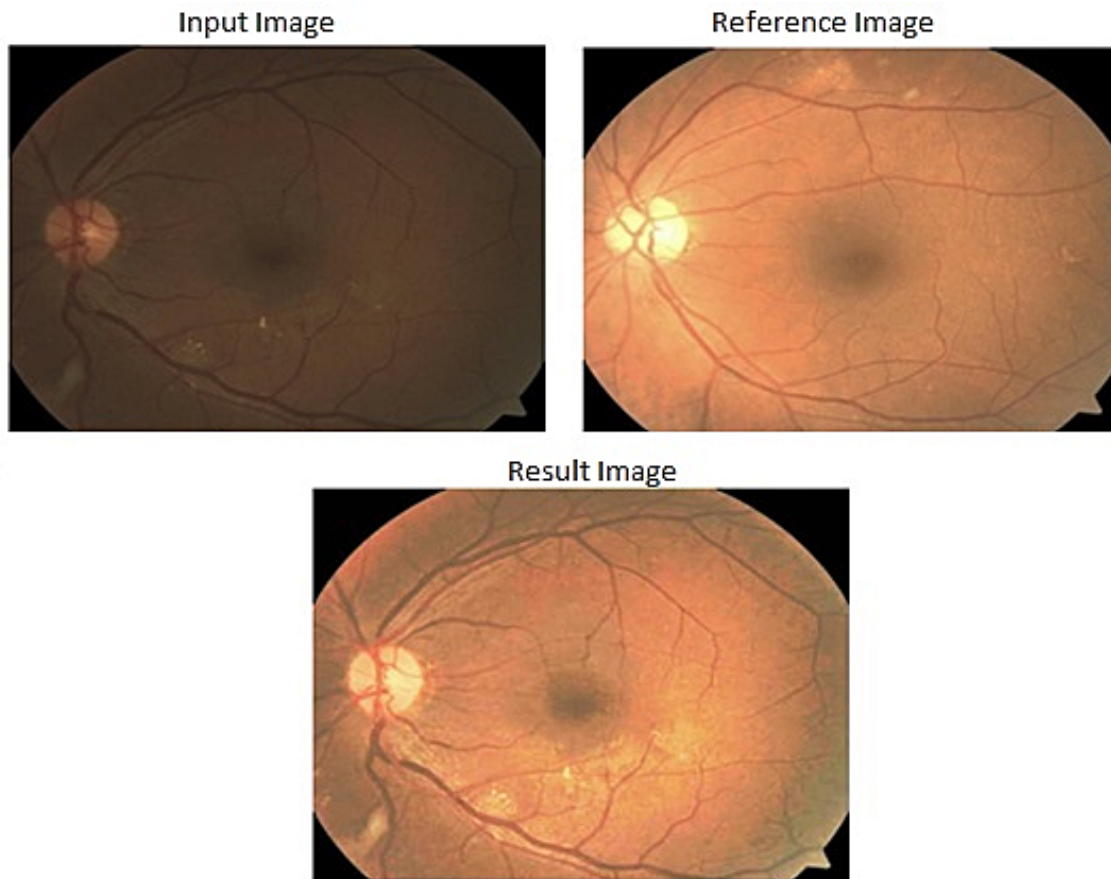


Figure 3.4: Image of Retinal, reference image and Output Image

Reference Image



Input Image



Result Image



Figure 3.5: Input image, reference image and output image

## Chapter 4

## Conclusion

In this thesis, methods that we applied balances the requirements of both appearance enhancement and being faithful to the original appearance of an image has been proposed and applied to the enhancement of full color images. Results have shown the effectiveness of our algorithm in improving the contrast and colorfulness of the original images. In this paper, we have shown that we can get better image from histogram specification with our own proposed histogram and 3 methods of histogram equalization on color image gives us better results.

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